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CLIMATE CHANGE AND UK ELECTRICITY NETWORK CAPACITY

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The current-carrying capacity (ampacity) of overhead conductors within the electricity network is limited by the thermal properties of their constituent materials. At the limit of a line's design capacity (or thermal rating), exceeding a pre-defined temperature will result in sag – where the line may become too close to the ground – or loss of strength. Current flowing through a line causes a heat gain, known as 'joule heating'. Radiative and convective cooling effects counteract some of the heat gain but in instances of higher ambient temperature, less cooling will occur and thus allowable levels of current will be more limited.

Generally in the UK, the thermal ratings of conductors are calculated by network operators as 'static' long-term properties, assuming typical mean seasonal temperatures of 20°C in summer, 2°C in winter and 9°C in autumn and spring (ENA, 1986), and often using conservative estimates of the other contributing factors such as wind speed (IEEE, 2007). However, climate change models indicate rises in mean temperature in all seasons, which will reduce the current assumed ratings. Alongside this, as the penetration of renewable energy increases, particularly on low voltage networks, the networks will be more likely to need to carry larger currents. This combination of warming and greater loads could present a capacity problem for network operators.

The United Kingdom Climate Projections 2009 (UKCP09)ⁱ provide the most high resolution and up-to-date probabilistic modelling of climate change in the UK. UKCP09 provides projections for 30 year time periods from 2010 to 2099 under three future emission scenarios (low, medium and high). In order to carry out a basic analysis of how temperature change – as projected by UKCP09 – could affect conductor ratings in the UK area, a subset of data containing the changes in mean summer and winter temperatures for a selection of future time periods and probability levels under the 'medium' emissions scenario were extracted. Using the IEEE Standard (2007), the thermal rating of a common type of conductor ('lynx') was calculated under current summer and winter temperatures as well as under future scenarios in which current temperatures were increased by the changes described by UKCP09. The results indicate that by the 2050s, in the case of a temperature increase at the 90% probability level, the average thermal rating of a lynx conductor decreases by up to 4.5% in the worst-affected region. A change at the 10% probability level results in a decrease of between 1 and 2% in rating. The winter temperature changes are, in general, smaller than those in summer and so the resulting decreases in conductor rating are proportionately less.

Taking this analysis a step further, it is clear that the worst case scenario for network operators will occur under conditions of maximum seasonal temperatures and may vary over the UK regions. By calculating the thermal rating of this hypothetical conductor based on current gridded (25km) long-term average summer maximum (rather than mean) temperaturesⁱⁱ over the whole area and comparing these to ratings calculated from temperatures perturbed by the future projected changes (on the same 25km grid), the spatial variability of the worst case scenarios can be analysed.

The decreases for the 2050s at the 10% probability level are between 0.5 and 1.5% from the baseline, but under the ‘worst’ scenario for this time period (90% probability), as shown in Figure 1, the rating shows significant drops. In percentage terms, the changes in rating range from around a 3.5% decrease in the northern part of the country to a 7.5% decrease in the southernmost regions. As the southern half of the UK already experiences higher peak summer temperatures, it follows that the lowest ratings are seen in this region. The UKCP09 model projects greater temperature rises in the south, further increasing the difference between maximum temperatures in the two regions, and consequently giving rise to greater differences in thermal ratings over the country.

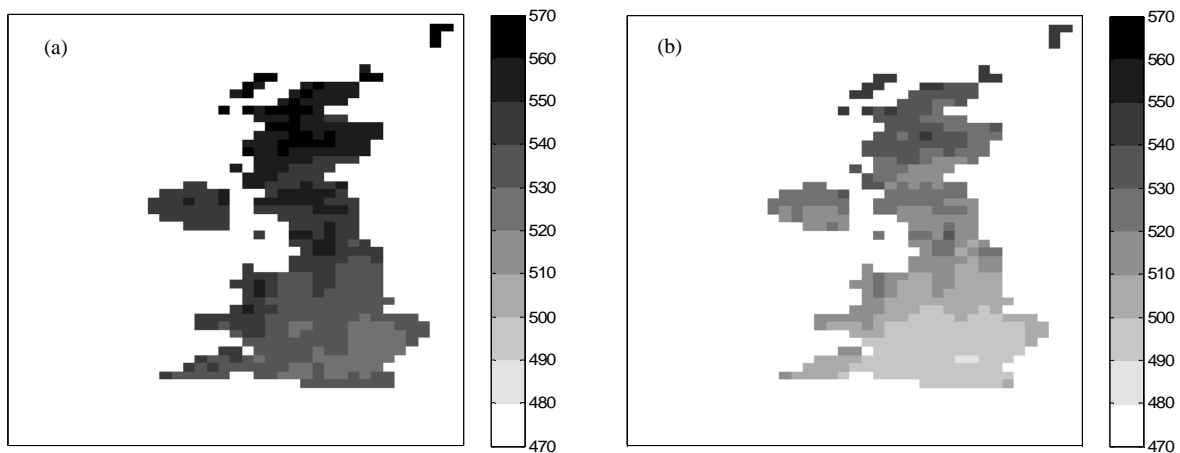


Figure 1: Ratings calculated at maximum summer temperature for (a) the baseline period and (b) 2050s @ 90% probability level (Amperes)

From the analysis of the mean changes, the summer season is clearly more vulnerable to thermal limitations due to the higher temperatures experienced. The point of greatest concern is the change in the summer maximum temperature, particularly in the southern half of the UK. The connections for renewable generation tend to be considered more likely in northern areas where resources are greater, and there is somewhat less vulnerability to thermal capacity constraints here. However, a further consideration is the possibility of increased electricity demand in periods of hot weather (Parkpoom & Harrison, 2008). This will be more probable in southern areas due to higher temperatures, and potentially more severe due to a higher population density in the south. Network operators may need to consider using dynamic real-time calculation of line ratings taking local weather variables into account, rather than using seasonal averages, which may allow for some mitigation of the possible problems.

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